or pinkish glow. Dr. Howard found some hailstones that were cylindrical in form; those that I found were approximately round but for the sharp edges of crystalline structure. Mr. B. Davies measured one and found it to be 3·5 centimetres in diameter. All the large stones that I found showed the same construction; in every one there was the same frilled appearance of an internal surface: this was also observed by Mr. B. Davies.

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THE SUBDIVISION OF THE ELECTRIC LIGHT.

TEN years ago the subdivision of the electric light was the burning question of the day. Again it has been revived, but the present subdivision is a legal and not an electrical problem.

The public interest in electricity roused by the sensational telegrams about Edison's work in 1878-79, and by the wonders seen at the Paris Electrical Exhibition in 1881, as well as at the Exhibition at the Crystal Palace in the following year, made people reflect that the electric lighting of our streets and houses might breed a monster as tyrannical as the water companies; consequently, paternal legislation passed an ill-considered Bill, the "Electric Lighting Act of 1882," to curb electrical repaciousness.

But had our law-givers paid attention to what was taking place in the City, and had they also possessed some acquaintance with the difficulties connected with the problem of electric distribution, they would have seen that it was on the Stock Exchange that the devouring electric Hydra was rampant, and that the general supply of electricity was in 1882 but a weak puny infant, which would require the most tender care to enable it to reach boyhood. Instead, however, of fostering the babe, the framers of the Act of 1882 showed their absolute ignorance of the way in which a new industry grows up, by introducing a clause which specified that at the end of twenty-one years the local authority might take over any installation for electrically lighting a district on paying the simple market value of the land and plant without giving anything for good-will. In view of the improvements in electrical machinery that might be expected to take place in twenty-one years, it might have been anticipated that before the end of this period the dynamos and other apparatus might very properly have been replaced twice over, in each case more efficient apparatus being substituted for less perfect: but the local authorities were still to be empowered to step in, to disregard all that had been done in building up a good business, and purchase the whole as a going concern for the mere market value of the land and plant. Hence the progress of electric lighting in England was strangled at its birth, while vast sums were squandered on the legalized gambling of the Stock Exchange, the public being unmercifully fleeced, and then left without electric lighting or belief in it.

This instance of paternal legislation was but a repetition of the one-sided Act passed to remedy the extortion that sometimes accompanied the operation of bills of sale. In this case the interests of the borrower were alone present in the minds of the framers of the Act, and they quite forgot that by making the recovery of debts on bills of sale very difficult they would introduce a new and even greater hardship, by making the borrowing of money on bills of sale frequently impossible.

This bone of contention, the Electric Lighting Act of 1882, was steadily snarled over and growled at, until last year the two Houses of Parliament saw fit to swallow a new Act, which, by extending the period of compulsory purchase to forty-two years, and by recognizing that the development of an electric light installation might represent something much more valuable than the market value of the land and plant, has at last made the general distribution of the electric current commercially possible.

But in the meantime, over a vast area extending from Regent's Park on the north to the Thames on the south, from the Law Courts on the east to Park Lane on the west, some thousands of electric lamps had been dotted, all fed from one central station in the basement under the restaurant of the Grosvenor Gallery in Bond Street. And to avoid the difficulties that would be introduced by the clauses in the 1882 Electric Lighting Act, if the streets were broken up and the wires put underground, the London Electric Supply Corporation, to whom the Grosvenor Gallery installation belongs, erected their cables, some 50 miles in length, over the tops of the houses. Hence, the legislation that was intended to avoid a vested interest being acquired in street conduits has forced the erection on the house-tops of a network of high-pressure mains which have now to be specially legislated for.

The productive capacity of the Grosvenor Gallery plant having been fully reached, while applications to supply current for thousands of incandescent lamps had to be shelved for want of means of generating the necessary current, the London Electric Supply Association commenced the erection of a vast station on the banks of the Thames at Deptford for the supply of current for some millions of incandescent lamps; and it has been mainly due to the application on the part of the company to obtain powers to run their wires along twenty-seven railways and tramways, and through thirty parishes, that the recent inquiry by the Board of Trade, lasting from April 3 to May 1, has been held to examine into the whole question of the electric lighting of London. The result of this inquiry is contained in a long Report that has just been submitted to the Secretary of the Railway Department of the Board of Trade by Major Marindin, this Report being agreed to by Major Cardew.

Eight companies—viz. the Chelsea Electricity Supply Company, the Electrical Power Storage Company, the House to House Electric Light Supply Company, the Kensington and Knightsbridge Electric Lighting Company, the London Electric Supply Corporation, the Metropolitan Electric Supply Company, the Notting Hill Electric Lighting Company, and the Westminster Electric Supply Corporation—applied for thirteen provisional orders and two licenses. A license is a permission granted for seven years, but it is renewable at the end of this period. The Board of Trade, however, can only grant a license when the consent of the local authority has been previously obtained. A provisional order, on the other hand, requires no consent of the local authority of the district, and is granted for a period of forty-two years. After a provisional order has been approved of by the Board of Trade, it requires to be confirmed by a Bill in Parliament before it can come into force. Neither the license nor the provisional order when granted is exclusive or creates any monopoly.

The first point considered in Major Marindin's Report is the systems of supply proposed to be used by the various companies applying for powers. They may be divided into a supply by direct current, and a supply by alternate current. The direct supply by means of continuous currents is dealt with under three heads:—(*a*) The system adopted by the Chelsea Company—viz. the use of one generating station for a considerable area, supplying current to charge several accumulator stations at different points within the area of supply with a pressure of from 1000 to 2000 volts, each station having a duplicate set of accumulators. The supply mains leading from these accumulator stations are intended to carry the current directly into the houses at a pressure of 100 volts, the supply being entirely from the accumulators. This is the system of transformation that was originally suggested by Sir William Thomson at the meeting of the British Association at York. (*b*) The system adopted by the Kensington and Knightsbridge Company, which is at the present moment supplying partly by accumulators and partly by dynamos—the former doing the whole work during the hours of minimum supply, and the latter being employed in charging the accumulators and supplementing the direct supply from the accumulators during the hours of maximum supply. The accumulators are all stationed at the generating station, and merely serve as a reserve of power. Since they are not employed to effect a transformation from a high to a low pressure, they do not introduce any saving in the size of the distributing mains, as in the case of the Chelsea system. Hence the Kensington system, which the Notting Hill Company proposes also to adopt, would require several generating stations for the lighting of a large area. (*c*) Direct supply at low pressure without the use of accumulators, such as is at present employed by the St. James's and Pall Mall Company. This system is also only suited for distribution over small areas, not exceeding half a mile in radius, since the absence of any system of transformation necessitates the employment of very large conductors. This last system has also the disadvantage of alternate current distribution, as the supply, being directly dependent on the steady working of the machinery, is liable to be seriously affected by even a temporary breakdown, which is, of course, not the case with the direct current systems (*a*) and (*b*).

It is interesting to note that no system of direct current transformation, other than that effected by the use of accumulators, has been proposed by any of the companies or referred to in Major Marindin's Report; probably because all direct current transformers, "motor-dynamos," &c., that have yet been devised, employ moving parts, and are therefore in their present form unsuitable for transformation in private houses. We cannot, however, but think that such direct current transformers might be very economically employed at distributing stations, the energy being received at high pressure from the main generating station, and distributed at low pressure to the houses in the neighbourhood of the distributing stations.

The House to House, the London Electric Supply, and the Metropolitan use high-pressure alternate currents with transformers, except in the case of the Whitehall installation of the last company; and it speaks well for the alternate current system that, while the Metropolitan Company commenced at Whitehall with direct currents and accumulators, which they first thought so superior to the use of alternate currents, they now state in their evidence that in their extensions they propose employing alternate currents and transformers. In the case of the London Electric Company, a *double system of transformation* is to be employed between the current leaving the dynamo and the current in the houses of the consumers. The supply will be obtained from a very large generating station at Deptford, outside the crowded districts of the Metropolis, and carried through trunk mains, at the unprecedentedly high pressure of 10,000 volts, to transforming stations inside, or near, the area of supply, whence the current will be taken by distributing mains, at a pressure of 2500 or 2000 volts, to the consumers' premises, and transformed there to 100 or 50 volts. Or this second transformation may be effected at secondary transforming stations, the currents being conveyed from them to the houses at the pressure of 100 or 50 volts.

In the case of the House to House and Metropolitan Companies only one transformation is proposed to be employed, so that several generating stations must be erected; as even with a pressure of 2000 volts the conductors would have to be inconveniently thick if the electric energy were conveyed very far. The Metropolitan Company have, therefore, selected sites in Sardinia Street, Rathbone Place, South Mews (near Manchester Square), Eccleston Place, and Waterloo Bridge Wharf; from each of which a current at 1000 volts will be sent, to be transformed into 100 or 50 volts inside the consumers' premises.

The Report contains a concise account, written by Major Cardew, of the relative advantages of the direct and of the alternate systems. He refers to the fact that the employment of accumulators by the Chelsea Company at their distributing stations enables small distributing mains to be used; makes the lighting of the district unaffected by even a temporary total breakdown of the machinery, since the accumulators that are at any time supplying current to the houses are quite distinct from those that are being charged; enables a nearly constant pressure to be maintained at the houses, independently of the number of lamps that are turned on; and, lastly, the current being a direct one is applicable for the supply of motive power and for other uses besides the production of light and heat, and can be more easily measured than an alternate current. Major Cardew further adds, as an additional advantage possessed by supplying current from accumulators, that "there is no doubt that a battery current is less destructive to lamps than one supplied from dynamos, whether alternating or continuous." We doubt, however, whether there is sufficient experimental evidence on this subject to justify this conclusion.

As a set-off to these advantages the cost of accumulators is great, as well as that of the skilled attention they require, while their efficiency at maximum output is probably rather low; the automatic switches for switching the accumulators into the charging circuit when discharged and into the discharging circuit when charged, as well as for regulating the discharge from each cell, are, Major Cardew thinks, a weak point, and any failure in their action would probably ruin the accumulators; the insulation of large batteries cannot be maintained at all high; and the numerous joints that have to be maintained good in the presence of acid fumes are a source of weakness.

The special advantages of the high-pressure transformer system Major Cardew considers to be: the smallness of the mains; the absence of difficulty in maintaining constancy of pressure in the mains within 2 per cent. over a large area; the pressure in the houses may be different in different cases according to the needs of the consumer; the system is simple to work; the dynamos are simple, and can be made in easily replaceable parts.

The disadvantages are that the high pressure necessitates great care and expense in insulation; the conveying of this high pressure to at any rate one point on the consumer's premises involves some risk to life; the main cannot be handled nor connection made with it when the pressure is on; the transformers cause the regulation in the houses to be not so good as in the mains; the system cannot at present be efficiently utilized for motive power, or for electric deposition or other chemical uses, such as charging accumulators; "and it is very doubtful whether a practically successful alternating motor is likely to be brought out"; the system depends entirely on running machinery; the general efficiency must be low when the supply is near its minimum, which, so long as it is utilized for lighting alone, obtains during about eighteen hours out of the twenty-four; a serious accident at the generating station might stop the supply. "Alternating machines cannot be so readily connected together to run in parallel circuit as continuous current machines"; the instruments and methods for making measurements are far more restricted in number, and the measurements are more difficult to make, when alternate currents are in question.

The sentences in the preceding paragraph that are placed in inverted commas appear to us to be particularly rash. So far from saying "it is very doubtful whether a practically successful alternating motor is likely to be brought out," we should prefer to say that it is almost certain that, as soon as there is a widespread demand for cheap efficient alternate current motors, such motors will be forthcoming; and, after the experiments shown by Mr.

Mordey at the end of May, at the factory of the Anglo-American Brush Company, on the great facility with which alternate machines can be coupled in parallel, Major Cardew must, we think, wish that he had worded the sentence quoted above somewhat differently.

Major Cardew next criticizes the objections that have been urged against the particular scheme involving two transformations of the pressure, which the London Electric Supply Association are arranging to carry out: that having only one generating station an accident might stop the whole supply of current to hundreds of thousands of incandescent lamps. To avoid, for example, the bursting of a steam-pipe greatly impeding, if not entirely stopping, all work by filling the factory with steam, and by the steam condensing on the dynamos and fittings, and so causing the high-pressure current to flash where it ought not to go, Major Cardew recommends that the Company shall subdivide the station at Deptford so as practically to provide two distinct generating stations, or shall forthwith establish a second generating station in some other locality. With reference to another objection, that the proposed pressure of 10,000 volts is so enormously in excess of anything which has hitherto been worked with, as to cause the scheme to be a gigantic experiment, he very rightly points out that, as there has been successfully used for some time at the Grosvenor Gallery installation over ten times the pressure that was believed to be the limit of safety a few years ago, "and as the so-called experiment of still further raising the limit of pressure would, if successfully carried out, be of immense benefit both to the public and electric light undertakers, I do not consider that, under proper regulations, the London Company should be prevented from carrying out a scheme in which they have shown the greatest confidence, and which the majority of scientific witnesses who have been called approve of in principle." With this recommendation we heartily agree, since all past history has shown that it is better to be guided by experience than by preconceived notions.

The final conclusions arrived at in the Report embrace several pages, but they may be briefly summed up as follows:—"That it must be admitted that the science of electric lighting has now reached the point at which a supply can be made which will be of great benefit to the public, and that the power of obtaining this supply should be within the reach of all persons who may require it," and therefore, although the wishes of local authorities should be consulted, "the mere objection by a local authority to the introduction of a company proposing to supply electric light, upon general grounds, should not be considered sufficient to exclude such company." As the whole Metropolis may be for purposes of lighting and management of roads and streets under the control of one central authority, "the provisional orders granted for the Metropolitan area should, as far as possible, be identical in form, with identical provisions as to supply, compulsory powers, interference with streets, and more than all as to price."

That the scheme adopted in 1883, of dividing a district into two areas (A) and (B)—the former an area that it was compulsory for the company obtaining the provisional order to light; the second an area which the company might light if they thought fit, but which they could not be required to light until after the expiration of two years—be abandoned, as such a distinction of areas is not likely to work well, and is not contained in the Electric Lighting Act, being merely introduced for the purpose of convenience; and that instead the supply shall be compulsory, under requisition, over the whole area on equal terms. That, "taking the (Metropolitan) area as a whole, it does not appear that it would be wise to fix a lower maximum than 8*d.* per unit." One Board of Trade unit is one thousand watts for one hour, so that at three and a half watts per candle, which is a fair average efficiency for an incandescent lamp, if it is to have a decent life, and assuming that a sixteen candle-power gas-burner consumes 5 cubic feet per hour, the maximum price proposed for the electric supply is equivalent to gas at 7*s.* per 1000 cubic feet, or nearly three times the present actual cost of lighting by gas. In the draft provisional orders several companies have asked for the right to make a certain minimum charge irrespective of the amount of electric energy consumed; and in the case of the Metropolitan Company, they ask to be allowed to charge a householder who has electric lamps in his house £5 10*s.* a quarter even if he never turns on a single lamp. Of course such a high minimum charge would be absurd, and even that of 13*s.* 4*d.* per quarter, which the Report appears to consider a reasonable one, appears to us much too high. In fact, we think that the proposal that there should be no minimum price at all if the householder pays for connecting his house with the mains might have been strongly urged in the Report, instead of it being stated that "such a provision would hardly be necessary where the minimum is reduced as in the Metropolitan Orders,"—that is, to 13*s.* 4*d.* a quarter. It is further recommended that there shall be a revision of the prices in the form of a sliding scale based upon the basis of a 10 per cent. dividend, the standard being fixed after the experience gained by the working of the first seven years.

In view of the fact that the laying of the mains of several companies means so much dead capital which the local authority would have to pay for if it elected to purchase at the end of forty-two years, and that no matter what regulations be made as to laying of mains the interference with the street must be to a certain degree proportionate to the number of companies having powers over this street, it is recommended that powers should not be given to more than two companies over the same area, and that one of these companies should be a company using the direct current. The following is very important, since if passed it will entail a vast expense on the London Electric Supply Corporation:—"That wherever a company now supplying a district by means of overhead wires is granted an order for such area, it should be placed under the obligation to remove these overhead wires within a period of two years from the granting of the order; and if such a thing be possible that this company should be prevented from invading a district in which it has not got powers by means of overhead wires."

At this Board of Trade inquiry many arguments *pro* and *con* were advanced as to the large companies being allowed to invade the areas that had begun to be worked by small companies. The large companies raised the "no monopoly" cry, and urged that they ought to be allowed to compete everywhere; whereas the smaller companies alleged that the most certain way to bring about monopoly would be to allow the large companies to enter the areas worked by the small companies, and to use the profits gained by the large companies in non-competing districts to enable them to work for a time at a loss in the competing district, and by underselling the smaller companies to eventually drive them out and have the whole field to themselves. Taking all points into consideration, Majors Marindin and Cardew recommend that there be allotted to—

(1) The London Electric Supply Corporation: the portions of St. Martin-in-the-Fields lying to the south of the Strand and west of St. Martin's Lane; the portion of St. Margaret and St. John, Westminster, lying to the north of Victoria Street, excepting that portion of St. Margaret lying to the west of St. George, Hanover Square; St. James, Westminster; St. George, Hanover Square; Chelsea; the Greenwich District; St. Mary, Rotherhithe; St. Mary, Bermondsey; the district of St. Olave; the district of St. Saviour, Christchurch; and that portion to St. Mary, Lambeth, lying to the north of Westminster Bridge Road.

(2) The Metropolitan Electric Supply Company: St. Giles-in-the-Fields; St. George, Bloomsbury; St. Andrew, Holborn, above Bars; St. George the Martyr; St. Sepulchre, Saffron Hill; Hatton Garden; Ely Rents and Ely Place; the Liberty of Glasshouse Yard; St. Anne, Soho; St. Paul, Covent Garden; St. John the Baptist; Savoy, or precinct of Savoy; St. Mary-le-Srand; St. Clement Danes and the Liberty of the Rolls; together with the extra-parochial places known as the Charter House, Gray's Inn, Lincoln's Inn, Staple Inn, and Furnival's Inn; St. Marylebone; St. Mary, Lambeth; St. Leonard, Streatham, and Clapham; that portion of St. Martin-in-the-Fields which lies to the east of Northumberland Avenue, Charing Cross, and St. Martin's Lane.

(3) The Chelsea Electricity Supply Company: the small portion of the parish of St. Mary Abbotts at the east end of the parish contiguous to Chelsea, which has already been agreed to by the Kensington Vestry; as well as the following, which has up to this time been refused by the Vestry of St. George, Hanover Square, viz. so much of the parish of St. George, Hanover Square, as is between the line formed by the eastern boundary of Chelsea parish on the west, by Knightsbridge, St. George's Place, and Hyde Park Corner, on the north, and by Grosvenor Place, Upper Grosvenor Gardens, Lower Grosvenor Gardens, Buckingham Palace Road, Commercial Road, and Bridge Road, on the east and south-east.

(4) The House to House Electric Light Supply Company: the south-western portion of the parish of St. Mary Abbotts, Kensington, which has been offered to this company by the Vestry, and which it is willing to accept.

(5) The Kensington and Knightsbridge Electric Lighting Company: the portion of the parish of St. Mary Abbotts, Kensington, which this company is at present lighting under licence from the Vestry; so much of the parish of St. Margaret, Westminster, as lies to the west of the parish of St. George, Hanover Square, which is at present worked under licence from the Vestry of St. Margaret and St. John, if the consent of this Vestry, which is at present refused to the issue of a forty-two years' provisional order, can be obtained.

(6) The Notting Hill Electric Lighting Company: the portion of the parish of St. Mary Abbotts, Kensington, which has been allotted to the company by the Vestry.

(7) The Westminster Electric Supply Corporation: the parish of St. George, Hanover Square; and the portions of St. Margaret and St. John, Westminster, lying to the south of Victoria street.

(8) As regards the Electrical Power Storage Company: that as the articles of association of this company do not give it any power to manufacture and supply electricity for house-to-house lighting no provisional orders be given.

Lastly, that the licenses applied for by the Chelsea and House-to-House Companies for areas in the portions of the parish of Kensington already allotted to these companies by the Vestry be granted.

As regards the City itself, the Commissioners of Sewers, acting for the Corporation, are asking for tenders; but Major Marindin says that he sees "no reason why the principle that all such lighting should be done under statutory powers and obligations should be departed from in their case;" and he recommends that the Board of Trade should "urge the Commissioners of Sewers to consider whether the orders as remodelled do not sufficiently provide for all their requirements, and to consent to a division of the area of the City between the two competing companies, viz. the London and Metropolitan Companies, the latter company being allotted the portion nearest the Strand District, and the former the Central and Eastern portions of the City, so that access may be given to the parish of Clerkenwell, the Vestry of which wishes for an order to be granted to this company."

Major Marindin's Report was forwarded on May 18, by the Board of Trade, to the London County Council, for an expression of their opinion on the subject; and the Clerk to the London County Council has within the last few days sent a reply to the Assistant Secretary of the Railway Department of the Board of Trade. In this reply, while expressing the general approval of the Council to the recommendations contained in Major Marindin's Report, he communicates the following important suggestions, among several others, which the London County Council desires to make:—

"That in the case of subways being in future made in streets where wires are already laid, the companies should be under an obligation to remove the wires into such subways, and to pay a rent for the use of them, a reasonable time (say three years) free of rent being allowed as a set-off to the cost of such removal."

Such a regulation it appears to us would be very onerous in the case of companies like the Kensington and Knightsbridge Company, who have gone to a considerable expense in making small special conduits for their own wires.

"That in view of future possible reduction in the cost of production which may be made as the result of experience and invention there should be a provision that the maximum price of 8*d*. per Board of Trade unit, proposed to be adopted, shall be subject to revision at the end of seven years; and that in order to insure healthy competition between the companies during that period no amalgamation or working agreement between companies shall be permitted without the consent of the Council. That clauses should be inserted providing for the application at the end of seven years of a sliding scale of price and dividend, on the basis of a dividend of 8 per cent." (not 10 per cent. as recommended by Major Marindin to the Board of Trade), "leaving the initial price and arrangement of the scale to be determined at the expiration of the term of seven years.

"That the minimum charge for supply should be fixed as low as possible, and that should such minimum be fixed at £1 per quarter or over it should be reckoned by the year and not by the quarter, because of the irregular requirements of the consumer at different seasons of the year."

We presume this is to prevent a company charging a householder by meter in the winter quarters, and levying the minimum rate in the summer quarter.

"The Council considers that it would be to the advantage alike of the public and the companies that there should be one uniform system of regulation and control throughout the entire area of London. The Council is of opinion that, as the representative governing body of the whole of London, it should be appointed the controlling authority. The Council would further suggest that, if it be made the controlling authority, it should be empowered to discharge the following duties, viz.:—

"Inspection of lines and works.

"Testing current.

"Testing and certifying meters."

We do not know whether the London County Council is aware that a Committee of the Institution of Electrical Engineers, and a Committee of the Electrical Section of the London Chamber of Commerce, have for some time past been engaged in advising Major Cardew regarding the details of an electrical standardizing laboratory to be fitted up for the use of the Board of Trade; and we think that, while municipal regulations may very properly be left to the County Council, the standardizing and certifying of meters would more appropriately form part of the work of that body which is already in charge of the national standards of weights and measures, viz. the Board of Trade.

The letter of the Clerk of the Council goes on to say:—

"The Council, in view of the fact that some companies have been, and are now, supplying electricity by overhead wires without statutory powers, and being convinced of the undesirability of allowing this to be continued, would venture to suggest that, in any further legislation on electric lighting, the supply of electricity in any district, before obtaining statutory powers for such district, should be prohibited under penalty."

To this we see no objection, now that the Electric Lighting Act is so modified that it is possible for an electric lighting company to reap commercial success by working under it.

THE LIFE-HISTORY OF A MARINE FOOD-FISH.[1]

II.

THE larval salmon enters the world of a size—though small—that is readily recognizable, viz. about three-fourths of an inch in length, but the marine forms under consideration, from their minute size and glassy translucency, are almost invisible to the naked eye—just a gleam of light broken by the passage of a different medium, or a tinge of pigment, arresting attention. Only in the cat-fish (which is not much—though it ought to be more—of a food-fish) with its large egg, have we a size nearly reaching that of the salmon at birth.

We had left the larval fish tossed about by the currents and unable to struggle against them, now floating with its yolk-sac uppermost, or hanging in the water with its head downward, and again making spasmodic darts hither and thither. Soon, however, it gathers strength, and at the end of a week or ten days it glides actively through the water, and avoids both obstacles and enemies, the young cod nimbly escaping the forceps, poising itself in the water with its large pectoral fins (Fig. 11), and evincing both intelligence and dexterity. Moreover, this activity greatly promotes respiration in those like the gunard with a motionless mandible, the water being thus sent through the mouth and over the branchial region. Its mouth has now opened and the yolk-sac has been absorbed, while it feeds on the most minute of the little Copepods, especially those almost microscopic in size, that swarm in the surrounding water. The provision whereby such tiny fishes find in the ocean food suited to their capacities is one of the most striking features in Nature, but it has only recently been carefully investigated. It is a notion no longer tenable that during the winter and spring the sea, to a large extent, is devoid of the wealth of pelagic life so characteristic of the summer months—just as it is of the genial waters of the tropics. For several years, however, it has been found that a vast abundance of minute life of all kinds is present throughout the entire year—and from the surface to the bottom. Moreover, during the warmer months a constant succession of young forms rises from the eggs both of the sedentary and creeping animals on the bottom to the surface, where they sport in the summer sun, undergo certain changes, and again descend as they assume the form of the adult. The pelagic young food-fishes—swimming freely in the ocean—thus have a double chance at them; first in their very early stage as they rise, and again in their larger and later condition as they descend. The enormous numbers, countless variety, and ever-changing nature of the small animals either directly or indirectly constituting the food of these little fishes form an important feature in the economy of the sea. Such animal forms comprise those long known in the British seas, besides others more familiar to Arctic voyagers, or to the sunny waters of the Mediterranean, for, with modern apparatus and persistent efforts (thanks to the enlightened views of the Government acting through the Fishery Board), our knowledge is always extending.

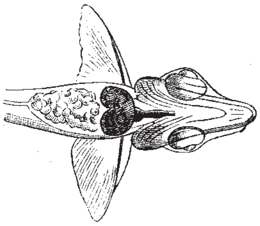

FIG. 11.—Ventral view of the anterior region of larval cod (magnified).

It is a remarkable fact that it is primarily to plants in inshore waters that the abundance and variety of animals are in many respects due, especially if estuaries also debouch in the neighbourhood. Thus nowhere are the swarms of Sagittæ, Appendicularians, Crustaceans, and other forms of fish-food more conspicuous than in the midst of a sea teeming with Diatoms, Rhizosoleniæ, and other Algoid structures.[1] These nourish many of the lower forms upon which the Crustaceans and other higher types feed, the latter again falling a prey to the fishes. Moreover, while the larger forms of the Copepods and other Crustaceans, for example, afford suitable nourishment for the more advanced post-larval fishes, the multitudes of larval Crustaceans (*Nauplii*) are adapted to the needs of the smallest larval food-fishes. Now this plant-life is specially abundant in April and May, just when the larval and very young post-larval fishes appear more abundantly in the inshore waters, so that the cycle is nearly complete, viz. from the inorganic medium through microscopic plant and larval Crustacean to the post-larval fish. I have mentioned the neighourhood of an estuary as a prolific source of food for young fishes, and I need only explain further by instancing the case of mussel-beds, which for months pour countless myriads of larval mussels into the adjoining sea, far beyond the needs of the area as regards mussel-culture, but which form a favourite food of the little fishes at all stages, but especially from an inch and a half to three inches in length. These fishes feed on the young mussels as they settle down on the sea-weeds, rocks, and zoophytes in August, after a free-swimming larval existence. Like some of the forms indicated above, mussels live to a considerable extent on microscopic plants and various minute organisms contained in the mud of the estuaries and other sites, so that a rich and favourite food, universally liked by fishes, is the product of these uninviting flats. Moreover, in passing, it may be remarked that, while everywhere preyed on by the food-fishes, it occasionally happens that in turn the mussel proves a source of inconvenience to them, for, settling on the gill-arches of haddocks, the mussels flourish on a site so suitable for aëration and food that they by and by press out the gill-cover and impede respiration, just as the shore-crab (which is also fond of mussels) has its eye-stalks wrenched out by the slow but sure growth of the young mussels which have fixed themselves in their sockets. Nemesis thus, by a chance of anchorage, converts a favourite food into a permanent inconvenience.

Again, in connection with the pelagic food of fishes, it is a well-known fact that adult cod are extremely fond of sea-anemones,[2] and some of the rarest species may be procured in their stomachs, a feature by no means surprising when we remember that Abbé Dicquemare cooked and ate his sea-anemones with great relish, and wrote in their favour, as also did Mr. Gosse in our own country. Now, the pelagic young fishes, instead of roaming near

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[1] A Discourse delivered by Prof. W. C. McIntosh, F.R.S., at the Royal Institution, on Friday, February 1, 1889.

[1] The fact that certain fishes feed on Infusoria has not been overlooked.

[2] A favourite bait for cod in some parts; and from the fact, amongst others, that star-fishes do not molest them on the hooks, no bait is more successful.